

/AN EVALUATION OF DISTRESS IN ASPHALT PAVEMENTS AND
SOME PREVENTIVE MEASURES/

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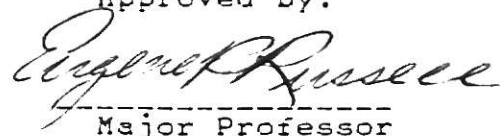
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I N T R O D U C T I O N

Over the past 100 years, and in an accelerated fashion in the past 25 years, the USA has developed an extensive road system. The main part of this system is a network of about two million miles of paved roads, that have an obvious impact on the economy, education, recreation, life style and national defense of the country. Realizing the vitality of roads to the country and to the individual, it is a matter of concern that there is a gradual decrease in its percentage of good milage, both rural and urban, as also stated by the Secretary of Kansas Dept. of Transportation during the March, 1985 Annual Transportation Conference at Kansas State University.

" ---29 percent of the state roads are deteriorating rapidly, and 11 percent have already deteriorated; ---- if nothing is done, 90 percent of the state interstate by 1990 would be classified as deficient---"

As a majority of total milage of roads in this country are asphaltic, the topic of this report is, " AN EVALUATION OF DISTRESS IN ASPHALT PAVEMENTS AND SOME PREVENTIVE MEASURES ".

As a natural phenomenon, any type of road starts wearing out once opened to traffic. The badly deteriorated roads not only cost more to maintain and rehabilitate, they drastically and adversely affect vehicle fuel consumption, operating costs, and traffic delays resulting in significant economic loss as shown in Figure 1 and Table 1.

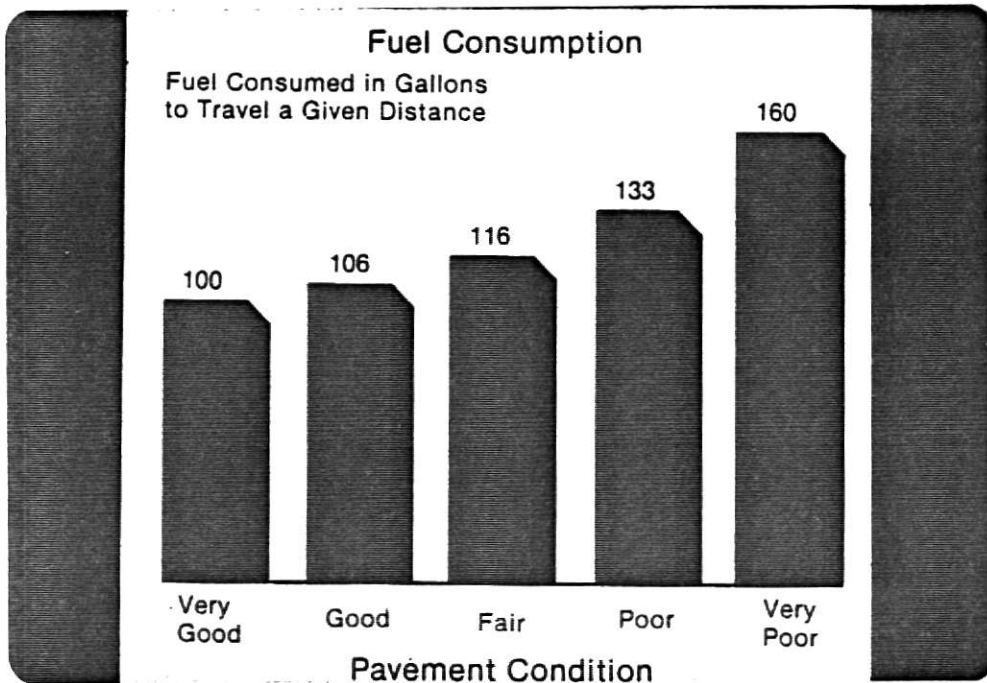


Fig. 1. FUEL CONSUMPTION. (From The Asphalt Institute, 1983.)

Table 1. (from The Asphalt Institute, 1983.)

ANNUAL COST OF BAD ROADS

- 12.5 BILLION GALLONS OF
WASTED FUEL
- \$19.5 BILLION IN VEHICLE
REPAIRS
- TENS OF THOUSANDS OF
DEATHS AND INJURIES

The key to good roads is timely maintenance, of which the initial step is to identify which pavements need immediate attention for maintenance purposes, and then to arrange a program of preventive measures according to their condition. The condition of the pavement is defined as a function of quality over its design life, which is the number of years a pavement is designed to serve the forecasted traffic identified at the time of design. The life cycle of a typical pavement is shown in Figure 2, where the quality of the pavement shown on the ordinate is defined as its ability to serve high speed, high volume, mixed traffic in its existing condition. It is basically related to the Present Serviceability Index (PSI) that provides an estimate of the subjective rating of the travelling public about its quality.

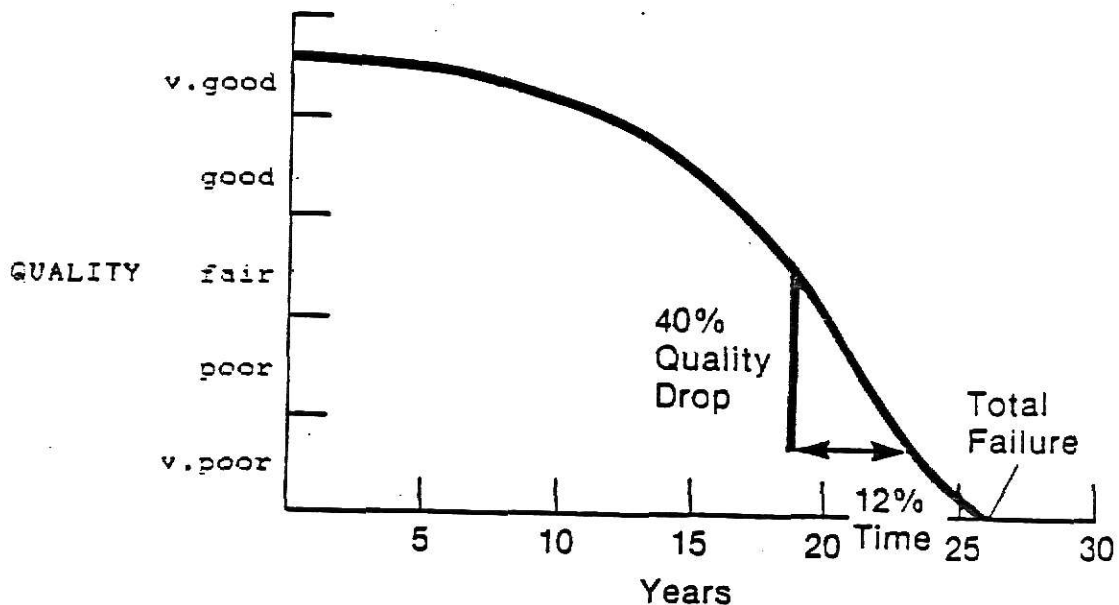


Fig. 2. PAVEMENT LIFE. (From Yoder and Witczak, 1975, and The Asphalt Institute, 1983.)

In a design life of twenty years, change in pavement condition during the first 8 to 10 years is minimal. Only after 15 to 16 years does a typical pavement cross the line from good to fair, having used up 75 percent of its design life. To return the pavement to good or new-like conditions, maintenance is required. However if maintenance is deferred at this stage, deterioration accelerates, the cracks become potholes and surface irregularities degenerate into rough surfaces, and within a short time the pavement condition drops another 40 percent from fair to poor and very poor, and then has to be re-constructed. This means that each dollar saved by deferring rehabilitation needed between the 15th. and 17th. year may cost five to six dollars in a short time of one to two years. Thus, timely maintenance not only saves money in the long run, it also extends the design life of the pavement as shown in Figure 3.

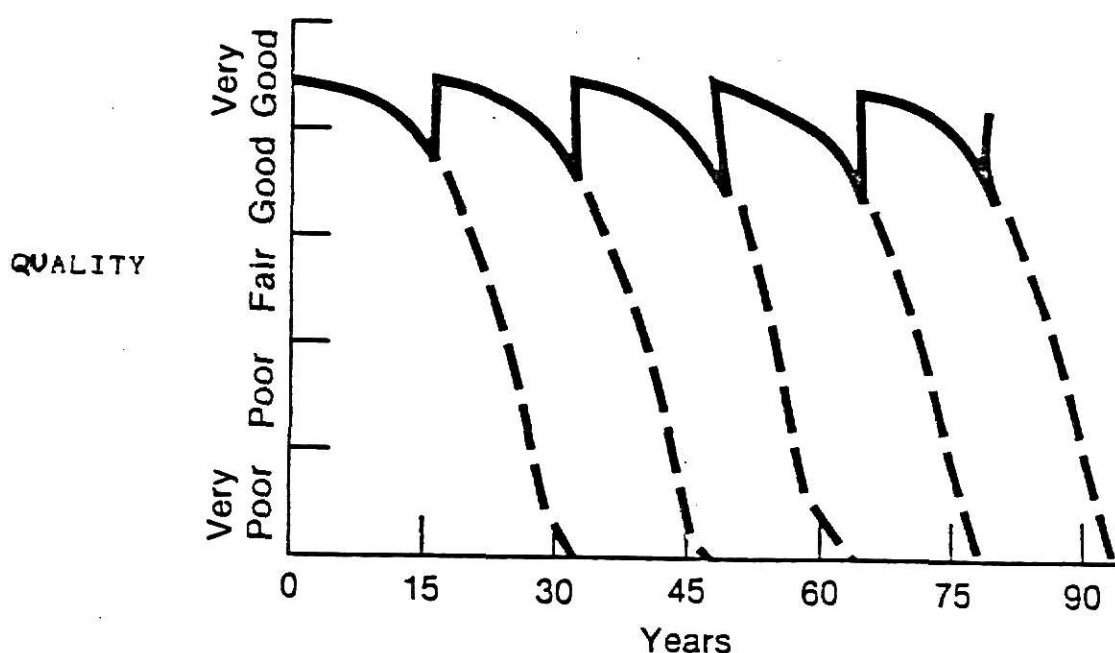


FIG. 3. TIMELY MAINTENANCE. (From Yoder and Witczak, 1975.)

A PAVEMENT MAINTENANCE PROGRAM

There are two types of maintenance activities:

- preventive maintenance,
- rehabilitative maintenance.

Preventive maintenance are the frequent measures taken by a road department to keep the pavement system functioning as intended and prevent failures known as "functional failures" of the pavement.

Functional failure is usually defined from the subjective rating of the pavement, and / or by means of deflection measurements, further illustrated in the section, "Roughness or Deflection Survey", that follows. The replacing of isolated failures, filling of cracks and improving drainage are examples of preventive maintenance operations, which if not carried out in a timely manner, result in structural failures of pavement.

Rehabilitative maintenance activities are those actions that must be taken when the pavement system, or portion of the system, must either be upgraded to accomodate heavier traffic or the condition of the pavement has reached from medium to severe type of "structural failure", and major action must be taken.

Structural failure is defined from identification of distress in the pavement which is the result of a detailed examination of different types of failures as described in the following sections.

D I S T R E S S I D E N T I F I C A T I O N

One of the basic measures of identifying structurally failed and also functionally failed pavements is their "existing distress". There are various kinds of defects and different severity levels for each distress type which, when known, provide great insight into pavement deterioration. Based on measurement of distress surveys and other informations such as roughness, and present serviceability index, a maintenance program can be selected. The distress survey is performed first, followed by a roughness survey and evaluation of serviceability.

D I S T R E S S S U R V E Y

A previous study (1) showed that the distress survey or categorization of distress into distinct types is controversial and variable between agencies and even between individuals within the same agency. The reason for this variability is variable design methods, different climatic conditions, different soil types, and various approaches towards distress diagnosis.

Significant progress has been made in the standardization of distress identification (1) (3) (5) (9). To properly identify distress, three factors must be considered:

1. TYPE: based on similar mechanisms or cause of occurrence.
2. SEVERITY: a given distress type can take place on a variety of severity conditions.
3. AMOUNT: the quantity and severity of each type is measured.

The description of each type of distress, its cause and measurements are described in the following pages. Severity of distress has been divided into three levels. These are somewhat arbitrary groupings, but generally provide distinct categories of the level of deterioration within the same distress type. In addition, the photographs of the distress showing various levels of severity are an indispensable part of the identification process. The following are some of the distress descriptions. (2) (3) (5) (9).

TYPE [1] SURFACE CRACKING

This is mostly considered a structural failure.

Name of distress: FATIGUE OR ALLIGATOR CRACKING.

Description and cause: Fatigue cracking, shown in Figure 4, is a series of interconnecting cracks caused by fatigue failure of the asphalt concrete surface or stabilized base under repeated traffic loading. The cracking initiates at the bottom of the asphalt surface layer or the stabilized base where the tensile stress and strain is highest under a wheel load as shown in Figure 5. The cracks propagate to the surface initially as one or more parallel cracks. After repeated traffic loadings, the cracks connect, forming many sided, sharp-angled pieces that develop a pattern resembling the skin of an alligator and hence is called alligator cracking. This type of cracking is considered as a major structural failure.

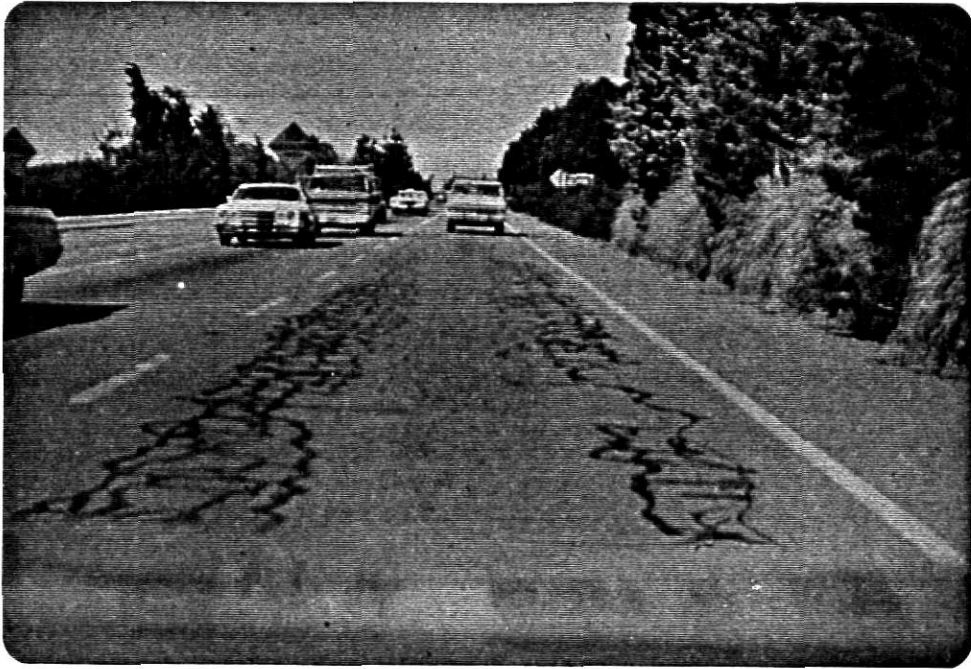


Fig. 4. FATIGUE OR ALLIGATOR CRACKING. (From U S Dept. of Transportation and Federal Highway Administration, 1984.)

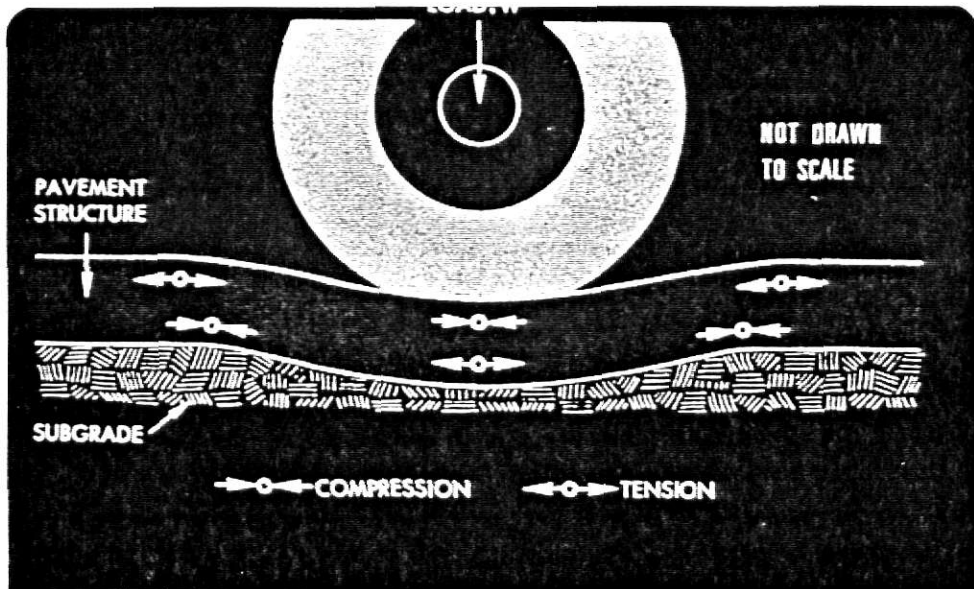


Fig. 5. MAXIMUM TENSION UNDER THE WHEEL LOAD. (From The Asphalt Institute, 1983.)

Severity Levels:

Low--- Longitudinally, somewhat connected minor cracks run parallel to each other. The cracks are not spalled and initially there may be a single, or just a few, crack(s) in the wheel path.

Medium--- Further development of low severity alligator cracking into a pattern of pieces formed by connected cracks that may be lightly surface spalled. (See Figure 6.)

High--- Medium alligator cracking that has progressed so that pieces are more severely spalled at the edges and loosened to move under the traffic. (See Figure 7.)

Measurement (Amount): Fatigue or Alligator cracking is measured in square feet or square meter of the affected surface area. The major difficulty in measuring this type of distress is that many times two or three levels of severity exist within one distress area. If these portions can be easily distinguished from each other, these are measured and recorded separately. However if the different levels of severity cannot be easily divided, the entire area should be rated at the highest severity level present.

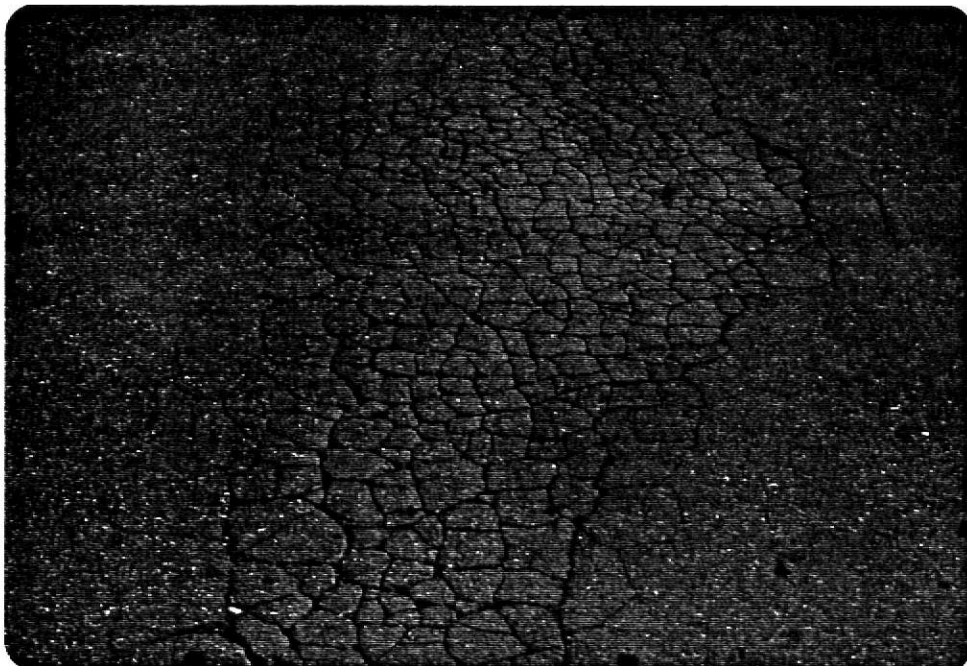


Fig. 6. MEDIUM SEVERITY FATIGUE CRACKING. (From U S Dept. of Transportation and Federal Highway Administration, 1984.)



Fig. 7. HIGH SEVERITY FATIGUE CRACKING. (From U S Dept. of Transportation and Federal Highway Administration, 1984.)

Name of distress: LONGITUDANAL, LANE JOINT, EDGE and
TRANSVERSE CRACKING.

Description and cause: Longitudnal cracks are parallel to the pavement centerline or laydown direction, whereas transverse cracks are perpendicular to it, as shown in Figure 8. They may be caused by poorly constructed paving lane joints or a weak seam between the pavement and the shoulder in the case of edge cracking, as shown in Figure 9.

Severity Levels:

Low: ---- Cracks have either minor spalling or no spalling and width of the cracks is not more than 1/4 of an inch as shown in Figure 10. No significant bump occurs when a vehicle crosses the crack.

Medium---- One of the following conditions exists: (i) cracks are moderately spalled; (ii) cracks are not spalled or have minor spalling but the previous sealing is such that water can freely infiltrate; (iii) crack width is greater than 1/4 of an inch; (iv) Low severity random cracking exists near the crack or at corners of cracks; (v) the crack causes a significant bump to a vehicle. (See Figure 11.)

High----- (i) Cracks are severely spalled and/or medium to high random cracking exists near the crack or at corners of intersecting cracks; (ii) crack width is greater than 1/2 inch; (iii) the crack causes a severe bump to a vehicle. (See Figure 12.)



Fig. 8. LONGITUDNAL AND TRANSVERSE CRACK. (From U S Dept. of Transportation and Federal Highway Administration 1984.)



Fig. 9. EDGE CRACKING. (From The Asphalt Institute, 1983.)

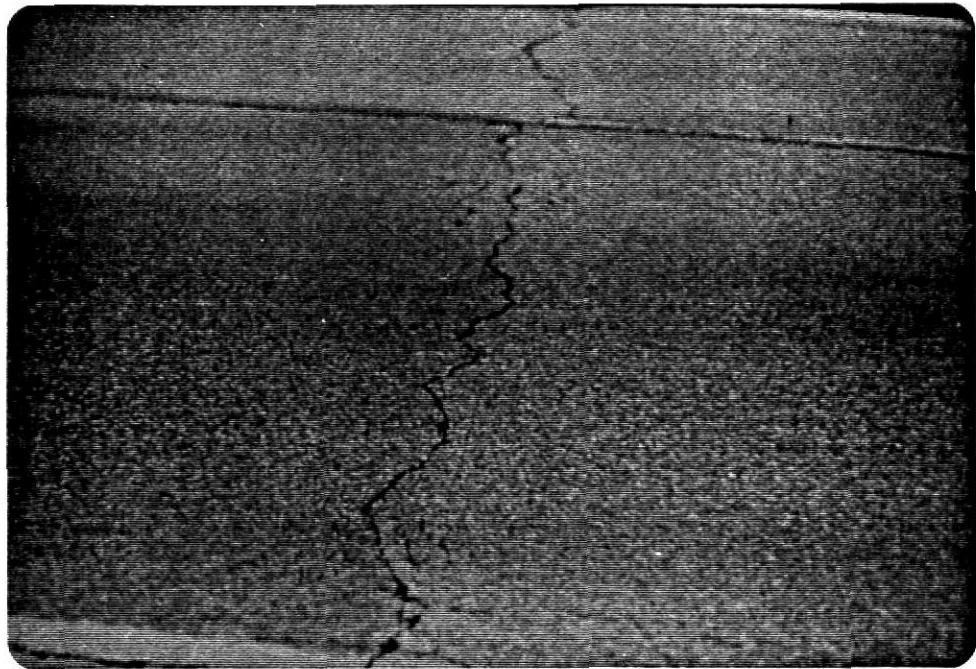


Fig. 10. LOW SEVERITY TRANSVERSE CRACK. (From U S Dept. of Transportation and Federal Highway Administration, 1984.)



Fig. 11. MEDIUM SEVERITY TRANSVERSE CRACK.
(From The Asphalt Institute, 1983.)

Measurement (Amount): The longitudinal cracks are measured in linear feet or linear meters. The length and severity of each crack is identified and recorded. The vehicle used to determine bump severity is a mid to full sedan weighing 3000 to 3500 lb. moving over the inspection section at the posted speed.



Fig.12. HIGH SEVERITY TRANSVERSE CRACK (From U S Dept. of Transportation and Federal Highway Administration, 1984.)

Name of distress: SLIPPAGE AND REFLECTION CRACKS.

Description and cause: Slippage cracks are crescent shaped cracks that usually point in the direction of the thrust of the wheel on the pavement surface as shown in Figure 13; however, they do not always point in the direction of the traffic. For example if brakes are applied down a hill the thrust of the wheels is reversed. Slippage occurring in this circumstance will result in cracks pointing uphill. The cause of such cracks is lack of good bond between the surface layer and the course beneath it. The lack of bond may be due to dust, oil, water or other non adhesive material between the two courses.

Reflection cracks are in asphalt overlays which reflect the crack pattern in the pavement structure underneath as shown in Figure 14. The pattern may be longitudinal, transverse, diagonal or block in the asphalt overlays on a portland cement layer or on an asphalt layer. They are most severe whenever cracks in the old pavement have not been properly repaired before construction of the overlay. Reflection cracks are caused by a vertical or horizontal movement in the pavement beneath the overlay, brought on by expansion and contraction with temperature or moisture changes. They may be caused by traffic or earth movements and / or by loss of moisture in subgrade with high clay contents.

Measurement (Amount): The level of severity and method of measurement is same as explained for other previously mentioned distress.



Fig. 13. SLIPPAGE CRACK. (From The Asphalt Institute, 1983.)



Fig. 14. REFLECTION CRACK. (From U S Dept. of Transportation
and Federal Highway Administration, 1984.)